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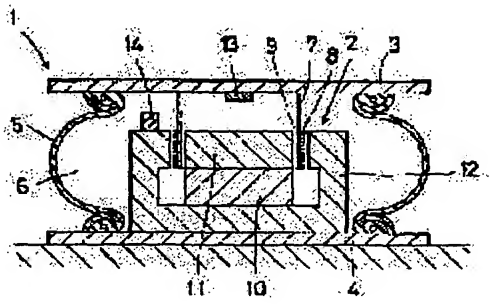
(54) VIBRATION ISOLATING DEVICE AND CONTROL METHOD THEREFOR

(57)Abstract:

PURPOSE: To prevent generation of vibration through control in a state wherein an air spring and an electromagnetic absorbing body are integrated in one body is a device which reduces the vibration of various industrial machines to microvibration for isolating the vibration with high precision, and forming the device in a compact structure and small size.

CONSTITUTION: A vibration isolating device comprises a voice coil motor 2 arranged in an air spring 1. In the air spring 1, a space between upper and lower plates 3 and 4 is tightly sealed by a bag body 5 and compressed air is fed in an air chamber 6. The voice coil motor 2 arranged in the air chamber 6 is formed such that the voice coil motor 8 is wound around a bobbin 7 and is inserted between the pawl piece 11 of a permanent magnet 10 having a gap 9 and an annular core 12.



LEGAL STATUS

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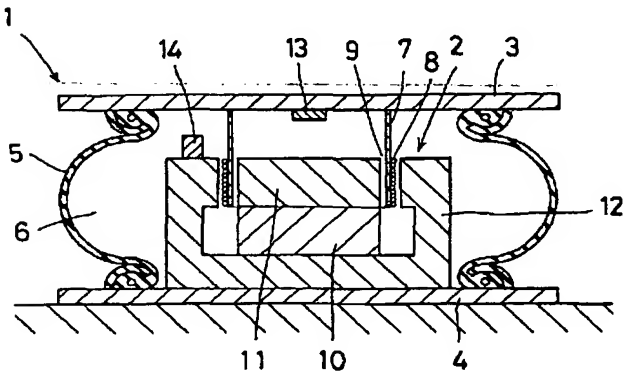
CLAIMS

[Claim(s)]
[Claim 1] The vibration isolator characterized by having had the air spring and the electromagnetic-force oscillating absorber, having prepared the either in the interior of another side, and unifying.
[Claim 2] The vibration isolator according to claim 1 characterized by considering as the voice coil motor which should enclose the compressed air with the interior of the bag body which consists the aforementioned air spring of an airtight elastic membrane, loops body material around a voice coil for an electromagnetic-force oscillating absorber, **** this in the opening between the annular magnets with which a magnetic pole counters radial, and changes.
[Claim 3] It is the vibration isolator according to claim 1 which unifies an electromagnetic-force oscillating absorber in preparation for the inside of the aforementioned air spring, and is characterized by consisting of what prepared the body which an electromagnetic-force oscillating absorber makes generate absorptive power or repulsive force with an electromagnet and an electromagnet, and carried out opposite arrangement of the minute gap to the electromagnet.
[Claim 4] both the output signals and the integration signals of the acceleration sensor which attached in the vibration isolator to the vibration isolator which unified and formed the air spring or the electromagnetic-force oscillating absorber in the interior of another side -- being based -- vibration of an oscillating absorber -- feedback control -- electromagnetism -- the control method of the vibration isolator which consists of controlling pneumatic pressure so that the air spring amount of compression becomes the set point based on both the output signals and the integration signals of the displacement sensor which controls-like and detects the amount of compression of an air spring [both / either or] / both / either or
[Claim 5] the output signal of the displacement sensor which detects the amount of compression of an air spring to the aforementioned vibration isolator -- differentiating -- the differential signal -- being based -- vibration of an oscillating absorber -- feedback control -- electromagnetism -- the control method of the vibration isolator according to claim 4 characterized by controlling pneumatic pressure so that it controls-like and the air spring amount of compression becomes the set point based on both the output signals and integration signals of the above-mentioned displacement sensor [both / either or]

[Translation done.]

Drawing selection [Representative drawing]



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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application] This invention relates to the vibration isolator used for vibrationproofing of various industrial machines, and its control method.
[0002]
[Description of the Prior Art] There is an air spring as one of the meanses which prevents vibration generated from various industrial machines, such as a dehydrator, a compressor, an air hammer, a press, and an oscillating conveyor. As shown in drawing 6 , generally this air spring encloses the compressed air with the interior of a cross-section ellipse-like bag body, uses the elasticity, and it consists of what fixed the outstanding rubber membrane (rubber bellows) of the airtightness reinforced with the powerful tire cord by vertical metallic ornaments.
[0003] When using this air spring as a vibration isolator, it consists of what generally installed the respectively independent thing of an air spring 1 and a voice coil motor 2 on the required-number common bed as shown in drawing 7 .
[0004] The example is shown in the paper (paper No.89-0916B) as which the vibration isolator using the air spring mentioned above was announced by for example, the Japan Society of Mechanical Engineers collected works (C pieces) and 56 No. 523 (1990-3), and "research of active fine oscillating vibration removal equipment which used the linear motor" (four persons besides Takashi Fujita).
[0005] In this paper, a voice coil form linear motor is used as an actuator of vibration removal equipment, and as the regular position maintained in a support table to weight change of a loading device, the pneumatic control of the air spring is carried out. And the above-mentioned linear motor coil detects the acceleration signal by the acceleration sensor, separately from a pneumatic control, integrates an integrator with this further to a speed signal, acquires a displacement signal, and after it changes these into a digital signal, it is controlled by computer control.
[0006] Similarly as other examples of the conventional vibration isolator, precision vibration removal equipment is indicated by the Japan Society of Mechanical Engineers collected works (C pieces), the paper (paper No.90-0829A) announced by 57 No. 534 (1991-2), and "active control of precision vibration removal equipment" (four persons besides Yoshiaki Iwata).
[0007] The vibration removal equipment of this example is made into an active system, like the first paper of the above, a linear coil motor is not formed but the method of controlling the servo valve which established near the entrance the air content instead sent into an air spring from an air supply is adopted. This control system sends the signal from the acceleration sensor installed in the base, and the displacement sensor prepared between a base and the base to a control system through an integrator, controls opening and closing of a servo valve by the command signal based on a relative displacement, acceleration, and a speed signal, and controls internal pressure.
[0008]
[Problem(s) to be Solved by the Invention] By the way, as pointed out also by the second paper mentioned above, it carries out to the high degree of accuracy of precision processing machines, such as

an electron microscope, laser equipment, and semiconductor-related, and improvement in the speed, and 1nm is made into an actual target, and the accuracy of measurement and the process tolerance have become until the influence of minute vibration influences the performance of a direct device.
[0009] Therefore, by the ultraprecise device, in the passive vibration isolator which forms an air spring etc., it is difficult to suppress minute vibration in tolerance, and asks for the active vibration isolator from which minute vibration is positively removable. And each of two above-mentioned papers aims at an active vibration isolator.
[0010] However, by the first thing, since an air spring and a linear coil motor distribute by arrangement suitably respectively and independently and it is prepared on the base, the whole device becomes large-sized, and as for the vibration isolator by the two above-mentioned papers, cost increases. Since the pneumatic control of an air spring and feedback control of the linear motor by the acceleration sensor are performed as a respectively separate system as the control method, there is a problem that it is still more insufficient for satisfying overly minute vibration removal conditions.
[0011] Moreover, it is larger for an effect to use together the damping force for overly controlling [of an air spring] minute displacement only by internal pressure to have inadequate oscillating depressor effect too, and according to a linear coil motor like the first paper, although enlargement of a device is avoided in what is depended on the second paper, since the method of controlling the internal pressure of an air spring by the servo valve is adopted.
[0012] Furthermore, although a several Hz thing is obtained and vibrationproofing of low frequency is possible for the resonant frequency of an air spring, near a opposite side resonant frequency, there is a problem that an amplitude is amplified also several times of an input, and a limitation is in the vibrationproofing effect in vibrationproofing of low frequency.
[0013] the present condition of the vibration isolator using the conventional air spring which mentioned this invention above -- minding -- an air spring and electromagnetism -- by unifying and constituting an oscillating absorber, are compact and let the miniaturized thing which can carry out vibrationproofing of from vibration of a low resonant frequency to the vibration of very minute high vibration frequency and for which a cheap vibration isolator is offered economically be a technical problem
[0014] the vibration isolator by which unification was furthermore carried out [above-mentioned] -- receiving -- the pneumatic control of an air spring, and electromagnetism -- let it be another technical problem to offer the control method that excite an oscillating absorber simultaneously, the oscillating removal by the vibration isolator is made to act effectively, and even minute vibration can be removed completely
[0015]
[Means for Solving the Problem] As a means to solve the first technical problem of the above, by this invention, it had the air spring and the electromagnetic-force oscillating absorber, and considered as the composition of the vibration isolator which prepared the either in the interior of another side, and was unified.
[0016] In this case, it is good also as composition of a vibration isolator used as the voice coil motor which should enclose the compressed air with the interior of the bag body which consists the aforementioned air spring of an airtight elastic membrane, loops body material around a voice coil for an electromagnetic-force oscillating absorber, **** this in the opening between the annular magnets with which a magnetic pole counters radial, and changes.
[0017] Or an electromagnetic-force oscillating absorber is unified in preparation for the inside of the aforementioned air spring, and an electromagnetic-force oscillating absorber is good also as composition of the vibration isolator which should prepare the minute gap to the electromagnet and should carry out opposite arrangement of the body made to generate absorptive power or repulsive force with an electromagnet and an electromagnet.
[0018] As a means to solve the second technical problem, moreover, in this invention As opposed to the vibration isolator which unified and formed the air spring or the electromagnetic-force oscillating absorber in the interior of another side It controls. both the output signals and integration signals of the acceleration sensor attached in the vibration isolator -- being based -- vibration of an oscillating absorber

-- feedback control -- electromagnetism ---like [both / either or] And it considered as the control method of the vibration isolator which consists of controlling pneumatic pressure so that the air spring amount of compression becomes the set point based on both the output signals and integration signals of the displacement sensor which detects the amount of compression of an air spring. [both / either or]
[0019] in this case, the output signal of the displacement sensor which detects the amount of compression of an air spring to the aforementioned vibration isolator -- differentiating -- the differential signal -- being based -- vibration of an oscillating absorber -- feedback control -- electromagnetism -- it is good also as the control method which controlled pneumatic pressure so that it controlled-like and the air spring amount of compression became the set point based on both the output signals and integration signals of the above-mentioned displacement sensor [both / either or]
[0020]
[Function] The vibration isolator of the above-mentioned composition is controlled by the method by invention of the control method. Control of a vibration isolator is performed from the 2nd page, control [controlling the pneumatic pressure of an air spring, and] vibration directly actively.
[0021] Also in this invention, it is very low, and the resonant frequency of the air spring itself is about several Hz. Pneumatic pressure is adjusted so that an attenuation factor may become large most with the size of the support load. This adjustment is performed by controlling the opening of a regulator valve based on the signal of a displacement sensor.
[0022] When controlling a regulator valve, it is performed by the combination of the signal and integration signal of a displacement sensor, and is made to make a variation rate into the minimum in proportion [directly] to the size of a displacement-sensor signal, and an integration signal is used for restricting to the value used as the average of the displacement signal in a predetermined time. A rough vibration can carry out ****** attenuation by this.
[0023] electromagnetism -- the oscillating absorber has made acceleration the variation rate as an oscillating absorption, it is fundamentally the same, and according to the vibration from a support load, although the voice coil motor or the electromagnet was combined and either is used -- it is -- measuring a variation rate directly -- the signal -- feeding back -- electromagnetism -- reaction is given-like, and it operates so that vibration may be negated by it
[0024] The reaction force by this electromagnetic force can suppress vibration completely by acting effectively also to a very minute variation rate, and making it act on the thing of the structure united with this within the air spring.
[0025]
[Example] The example of this invention is explained with reference to a drawing below.
[0026] Drawing 1 is the main cross section of the vibration isolator of the first example. This example shows the example which built the voice coil motor 2 as an electromagnetic-force oscillating absorber in the interior of an air spring 1.
[0027] The bag body 5 of the shape of a cross-section ellipse which consists of the excellent rubber membrane (rubber bellows) of the airtightness reinforced with the powerful tire cord between the finish plate 3 and the underplate 4 like the usual thing as an air spring 1 is attached, the compressed air is enclosed with the internal air chamber 6, and the air spring is formed using the elasticity.
[0028] Although there are some which have not formed the finish plate 3 and the underplate 4 depending on the form of an air spring, there should just be a member for attaching a voice coil motor in an air spring in that case.
[0029] Inserting in the above-mentioned crevice [winding] 9 between the magnets formed so that a voice coil 8 might be minded, the crevice 9 in a circle might be minded [which attached the voice coil motor 2 in the finish plate 3 / in a circle / 7] for this and a magnetic pole might counter radial, a magnet consists of the pole piece 11 of the permanent magnet 10 magnetized by N pole like illustration at the center side, and the iron core 12 in a circle magnetized by the outside at the south pole.
[0030] 13 is an acceleration sensor and 14 is a displacement sensor.
[0031] Drawing 2 is the main cross section of the vibration isolator of the second example. This example shows the example which built air spring 1' in the interior of voice coil motor 2'.

[0032] Air spring 1' consists of what prepared bag body 5' of the same rubber membrane as the first example between the magnet of voice coil motor 2' prepared between the finish plate 3 and the underplate 4, and the finish plate 3, and the compressed air is enclosed with the air chamber 6'.
[0033] Like the first example, voice coil motor 2' inserts a bobbin 7 and a voice coil 8 in a crevice 9, and consists of the permanent magnet 10 which has this crevice 9, and the pole piece 11 and the iron core 12 prepared in the outside. It has the acceleration sensor 13 and the displacement sensor 14 similarly.
[0034] Vibration of the device which the compressed air is sent into an air spring 1 and 1', and adjusts pneumatic pressure suitably when using it as a vibration isolator in any [of two examples constituted as mentioned above] case, and exerts electromagnetic force on a voice coil motor 2 and 2', and is installed in the upper part of a vibration isolator is prevented.
[0035] Drawing 3 is the main cross section of the vibration isolator of the third example. Although the electromagnetic-force oscillating absorber is built in the interior of an air spring 1 like the first example in this example, the composition of an electromagnetic-force oscillating absorber differs in a voice coil motor 2, and it differs in that electromagnet unit 2" which consists of the combination of an electromagnet and a permanent magnet is used.
[0036] Electromagnet unit 2" attaches in a finish plate what surrounded permanent magnet 7" by iron core 8", and consists of what looped this around coil 11" in a circle to predetermined distance ******** eclipse ****** 10." The acceleration sensor 13 and the displacement sensor 14 are formed too.
[0037] An air spring 1 forms a bag body 5 between a finish plate 3 and a underplate 4 like the first example, and consists of what enclosed the compressed air with the interior.
[0038] Also in the vibration isolator of the above-mentioned composition, static height adjusts the pneumatic pressure of an air spring 1 based on the displacement information acquired from a displacement sensor 14, and performs it. Attenuation of vibration is made to act so that the electromagnetic force of electromagnet unit 2" may be adjusted based on the acceleration signal of an acceleration sensor 13 and vibration may be negated.
[0039] The plan of the example which formed the vibration isolator of one of the above on the vibrationproofing base 20 or in the bottom at drawing 4 is shown.
[0040] The outline block diagram of the control circuit which controls the vibration isolator of the first example of the above to drawing 5 is shown. In addition, it will not be necessary to explain that it is controllable by the same control circuit, even if it is the thing of the second example and the third example, although the example of illustration shows the thing of the first example as a vibration isolator.

[0041] If this control circuit consists mainly of three equalization circuits and one of them detects an acceleration signal by the acceleration sensor 13, after a filter's 21 removing DC component (direct current) among the acceleration signal, taking out only a change signal component, and the gain-adjustment machine's 22 adjusting gain and adding with other signals through an adder 25, it is the circuit which controls power amplification 26 based on the signal, and sends drive current to a voice coil motor 2.
[0042] An integrator 23 and the gain-adjustment machine 24 are formed in the circuit of the above-mentioned gain-adjustment machine 22 in parallel, and the output signal is sent to it to an adder 25.
[0043] The 2nd equalization circuit is the system of the displacement signal by the displacement sensor 14, and is a circuit which will differentiate the signal with a differentiator 27 if a displacement signal is taken out, carries out the gain adjustment of the differential signal with the gain-adjustment vessel 28, and is added to an adder 25.
[0044] It is a circuit which controls reducing-valve 33' while the 3rd equalization circuit branches, sends the displacement signal of the above-mentioned displacement sensor 14 to the gain-adjustment machine 29, adds this to an adder 32 and controls a regulator valve 33 by the output signal. The circuit of an integrator 30 and the gain-adjustment machine 31 is established in the circuit of the gain-adjustment machine 29, and parallel in the circuit which controls this regulator-valve 33 grade. A regulator valve 33 adjusts the compressed air from the high-pressure air receiver 34, and adjusts a variation rate in the height of an air spring 1. Reducing-valve 33' is adjusted so that the internal pressure of an air spring 1

may become below the set point.
[0045] As mentioned above, the signal which expresses the change portion with an adder 25 except for a part for the direct current from an acceleration signal, the signal which integrated with the signal, and the signal which differentiated the signal further detected by the displacement sensor 14 are added, and excitation of a voice coil motor is controlled by the above-mentioned control circuit by the output. That is, PID control is performed.
[0046] In this case, an output signal is given to power amplification 26 by the signal component with the large rate of one of signals among the values to which time for each signal to become the largest differed according to the property of each change, therefore the first acceleration signal, the speed signal which integrated with this, and the differential signal of a variation rate were added with the adder 25, and a voice coil motor 2 is excited so that the change may be negated by the exciting current from power amplification 26.
[0047] On the other hand, a displacement signal and its integration signal are given to an adder 32 in the circuit which controls regulator-valve 33 grade by the signal of a displacement sensor 14. The opening of a regulator valve 33 and the set pressure of reducing-valve 33' are controlled by the signal with the large rate for which each signal accounts also in this case, and it is adjusted so that the pneumatic pressure in an air spring 1, therefore the height position of a finish plate 3 may serve as the set point.
[0048] Although the above was the example of the circuit which enforces the first control method, a part of above circuit should be combined as other examples of the control method (following illustration ellipsis).
[0049] For example, it is the combination (Systems I and III should put together) of the circuit which controls a voice coil motor by the above-mentioned acceleration sensor 13 as the second control method, and the circuit which controls regulator-valve 33 grade by the displacement sensor 14. Therefore, the circuit which sends the signal of a displacement sensor 14 to a differentiator 27 in this case is omitted.
[0050] The signal which differentiated the signal of a displacement sensor 14 with the differentiator 27 becomes the thing same as a result since it is a speed signal as the signal which integrated with the signal of an acceleration sensor 13, therefore even if it omits the circuit of a differentiator 27, it can perform the same control as the first control method.
[0051] The combination (Systems II and III should put together) of the circuit which forms only a displacement sensor 14, gives the signal to power amplification 26 through a differentiator 27 as the third control method, controls a voice coil motor 2, and controls regulator-valve 33 grade by the signal of the browning grade sensor 14 is employable. In this case, since the acceleration sensor 13 is not formed, an adder 25 is also omitted.
[0052] A voice coil motor 2 is controlled by the above-mentioned control circuit by the excitation from power amplification 26 to negate the variation rate of the size of the speed in proportion to the size of the speed signal of the circuit of System II. System III About an operation, it is the same as the case of the first example.
[0053] Therefore, also in this example, adjustment of the electromagnetic control of a voice coil motor 2 and the pneumatic pressure of the air spring by the regulator valve 33 is performed.
[0054]
[Effect] As explained to the detail above, in this invention, it should be compact, and the shell which considered the air spring and the electromagnetic-force oscillating absorber as the composition of the vibration isolator which contained either in another side and unified it, and the whole equipment should be miniaturized, and cost can be reduced, and an advantage, like design arrangement of the whole vibration isolator becomes advantageous is acquired.
[0055] invention of the method of controlling the above-mentioned vibration isolator -- the combination of an acceleration signal and its integration signal -- vibration of an oscillating absorber -- electromagnetism -- the first control method which controls-like and controls the pneumatic pressure of an air spring by combination of the signal and integration signal of a browning grade sensor -- or the signal which differentiated the signal of a displacement sensor -- vibration of an oscillating absorber -- electromagnetism, even if it is which [of the second control method which controls-like and controls the

pneumatic pressure of an air spring by combination of a browning grade sensor signal and its integration signal] case vibration of an oscillating absorber made into unification structure -- electromagnetism -- compared with the conventional method of performing individually control or each of only one of the shells made into the combination of the method of adjusting the pneumatic pressure of an air spring while denying-like to the oscillating absorber of another object structure it is markedly alike and suppression of a highly precise minute vibration is attained

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TECHNICAL FIELD

[Industrial Application] This invention relates to the vibration isolator used for vibrationproofing of various industrial machines, and its control method.

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PRIOR ART

[Description of the Prior Art] There is an air spring as one of the meanses which prevents vibration generated from various industrial machines, such as a dehydrator, a compressor, an air hammer, a press, and an oscillating conveyor. As shown in drawing 6 , generally this air spring encloses the compressed air with the interior of a cross-section ellipse-like bag body, uses the elasticity, and it consists of what fixed the outstanding rubber membrane (rubber bellows) of the airtightness reinforced with the powerful tire cord by vertical metallic ornaments.
[0003] When using this air spring as a vibration isolator, it consists of what generally installed the respectively independent thing of an air spring 1 and a voice coil motor 2 on the required-number common bed as shown in drawing 7 .
[0004] The example is shown in the paper (paper No.89-0916B) as which the vibration isolator using the air spring mentioned above was announced by for example, the Japan Society of Mechanical Engineers collected works (C pieces) and 56 No. 523 (1990-3), and "research of active fine oscillating vibration removal equipment which used the linear motor" (four persons besides Takashi Fujita).
[0005] In this paper, a voice coil form linear motor is used as an actuator of vibration removal equipment, and as the regular position maintained in a support table to weight change of a loading device, the pneumatic control of the air spring is carried out. And the above-mentioned linear motor coil detects the acceleration signal by the acceleration sensor, separately from a pneumatic control, integrates an integrator with this further to a speed signal, acquires a displacement signal, and after it changes these into a digital signal, it is controlled by computer control.
[0006] Similarly as other examples of the conventional vibration isolator, precision vibration removal equipment is indicated by the Japan Society of Mechanical Engineers collected works (C pieces), the paper (paper No.90-0829A) announced by 57 No. 534 (1991-2), and "active control of precision vibration removal equipment" (four persons besides Yoshiaki Iwata).
[0007] The vibration removal equipment of this example is made into an active system, like the first paper of the above, a linear coil motor is not formed but the method of controlling the servo valve which established near the entrance the air content instead sent into an air spring from an air supply is adopted. This control system sends the signal from the acceleration sensor installed in the base, and the displacement sensor prepared between a base and the base to a control system through an integrator, controls opening and closing of a servo valve by the command signal based on a relative displacement, acceleration, and a speed signal, and controls internal pressure.

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EFFECT OF THE INVENTION

[Effect] As explained to the detail above, in this invention, it should be compact, and the shell which considered the air spring and the electromagnetic-force oscillating absorber as the composition of the vibration isolator which contained either in another side and unified it, and the whole equipment should be miniaturized, and cost can be reduced, and an advantage, like design arrangement of the whole vibration isolator becomes advantageous is acquired.
[0055] invention of the method of controlling the above-mentioned vibration isolator -- the combination of an acceleration signal and its integration signal -- vibration of an oscillating absorber -- electromagnetism ---like -- controlling -- the combination of the signal and integration signal of a browning grade sensor the signal which differentiated the first control method which controls the pneumatic pressure of an air spring, or the signal of a displacement sensor -- vibration of an oscillating absorber -- electromagnetism, even if it is which [of the second control method which controls-like and controls the pneumatic pressure of an air spring by combination of a browning grade sensor signal and its integration signal] case vibration of an oscillating absorber made into unification structure -- electromagnetism -- compared with the conventional method of performing individually control or each of only one of the shells made into the combination of the method of adjusting the pneumatic pressure of an air spring while denying-like to the oscillating absorber of another object structure it is markedly alike and suppression of a highly precise minute vibration is attained

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TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention] By the way, as pointed out also by the second paper mentioned above, it carries out to the high degree of accuracy of precision processing machines, such as an electron microscope, laser equipment, and semiconductor-related, and improvement in the speed, and 1nm is made into an actual target, and the accuracy of measurement and the process tolerance have become until the influence of minute vibration influences the performance of a direct device.

[0009] Therefore, by the ultraprecise device, in the passive vibration isolator which forms an air spring etc., it is difficult to suppress minute vibration in tolerance, and asks for the active vibration isolator from which minute vibration is positively removable. And each of two above-mentioned papers aims at an active vibration isolator.

[0010] However, by the first thing, since an air spring and a linear coil motor distribute by arrangement suitably respectively and independently and it is prepared on the base, the whole device becomes large-sized, and as for the vibration isolator by the two above-mentioned papers, cost increases. Since the pneumatic control of an air spring and feedback control of the linear motor by the acceleration sensor are performed as a respectively separate system as the control method, there is a problem that it is still more insufficient for satisfying overly minute vibration removal conditions.

[0011] Moreover, it is larger for an effect to use together the damping force for overly controlling [of an air spring] minute displacement only by internal pressure to have inadequate oscillating depressor effect too, and according to a linear coil motor like the first paper, although enlargement of a device is avoided in what is depended on the second paper, since the method of controlling the internal pressure of an air spring by the servo valve is adopted.

[0012] Furthermore, although a several Hz thing is obtained and vibrationproofing of low frequency is possible for the resonant frequency of an air spring, near a opposite side resonant frequency, there is a problem that an amplitude is amplified also several times of an input, and a limitation is in the vibrationproofing effect in vibrationproofing of low frequency.

[0013] the present condition of the vibration isolator using the conventional air spring which mentioned this invention above -- minding -- an air spring and electromagnetism -- by unifying and constituting an oscillating absorber, are compact and let the miniaturized thing which can carry out vibrationproofing of from vibration of a low resonant frequency to the vibration of very minute high vibration frequency and for which a cheap vibration isolator is offered economically be a technical problem

[0014] the vibration isolator by which unification was furthermore carried out [above-mentioned] -- receiving -- the pneumatic control of an air spring, and electromagnetism -- let it be another technical problem to offer the control method that excite an oscillating absorber simultaneously, the oscillating removal by the vibration isolator is made to act effectively, and even minute vibration can be removed completely

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MEANS

[Means for Solving the Problem] As a means to solve the first technical problem of the above, by this invention, it had the air spring and the electromagnetic-force oscillating absorber, and considered as the composition of the vibration isolator which prepared the either in the interior of another side, and was unified.
[0016] In this case, it is good also as composition of a vibration isolator used as the voice coil motor which should enclose the compressed air with the interior of the bag body which consists the aforementioned air spring of an airtight elastic membrane, loops body material around a voice coil for an electromagnetic-force oscillating absorber, **** this in the opening between the annular magnets with which a magnetic pole counters radial, and changes.
[0017] Or an electromagnetic-force oscillating absorber is unified in preparation for the inside of the aforementioned air spring, and an electromagnetic-force oscillating absorber is good also as composition of the vibration isolator which should prepare the minute gap to the electromagnet and should carry out opposite arrangement of the body made to generate absorptive power or repulsive force with an electromagnet and an electromagnet.
[0018] As a means to solve the second technical problem, moreover, in this invention As opposed to the vibration isolator which unified and formed the air spring or the electromagnetic-force oscillating absorber in the interior of another side It controls. both the output signals and integration signals of the acceleration sensor attached in the vibration isolator -- being based -- vibration of an oscillating absorber -- feedback control -- electromagnetism ---like [both / either or] And it considered as the control method of the vibration isolator which consists of controlling pneumatic pressure so that the air spring amount of compression becomes the set point based on both the output signals and integration signals of the displacement sensor which detects the amount of compression of an air spring. [both / either or]
[0019] in this case, the output signal of the displacement sensor which detects the amount of compression of an air spring to the aforementioned vibration isolator -- differentiating -- the differential signal -- being based -- vibration of an oscillating absorber -- feedback control -- electromagnetism -- it is good also as the control method which controlled pneumatic pressure so that it controlled-like and the air spring amount of compression became the set point based on both the output signals and integration signals of the above-mentioned displacement sensor [both / either or]

[Translation done.]

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OPERATION

[Function] The vibration isolator of the above-mentioned composition is controlled by the method by invention of the control method. Control of a vibration isolator is performed from the 2nd page, control [controlling the pneumatic pressure of an air spring, and] vibration directly actively.
[0021] Also in this invention, it is very low, and the resonant frequency of the air spring itself is about several Hz. Pneumatic pressure is adjusted so that an attenuation factor may become large most with the size of the support load. This adjustment is performed by controlling the opening of a regulator valve based on the signal of a displacement sensor.
[0022] When controlling a regulator valve, it is performed by the combination of the signal and integration signal of a displacement sensor, and is made to make a variation rate into the minimum in proportion [directly] to the size of a displacement-sensor signal, and an integration signal is used for restricting to the value used as the average of the displacement signal in a predetermined time. A rough vibration can carry out ****** attenuation by this.
[0023] electromagnetism -- the oscillating absorber has made acceleration the variation rate as an oscillating absorption, it is fundamentally the same, and according to the vibration from a support load, although the voice coil motor or the electromagnet was combined and either is used -- it is -- measuring a variation rate directly -- the signal -- feeding back -- electromagnetism -- reaction is given-like, and it operates so that vibration may be negated by it
[0024] The reaction force by this electromagnetic force can suppress vibration completely by acting effectively also to a very minute variation rate, and making it act on the thing of the structure united with this within the air spring.

[Translation done.]

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EXAMPLE

[Example] The example of this invention is explained with reference to a drawing below.
[0026] Drawing 1 is the main cross section of the vibration isolator of the first example. This example shows the example which built the voice coil motor 2 as an electromagnetic-force oscillating absorber in the interior of an air spring 1.
[0027] The bag body 5 of the shape of a cross-section ellipse which consists of the excellent rubber membrane (rubber bellows) of the airtightness reinforced with the powerful tire cord between the finish plate 3 and the underplate 4 like the usual thing as an air spring 1 is attached, the compressed air is enclosed with the internal air chamber 6, and the air spring is formed using the elasticity.
[0028] Although there are some which have not formed the finish plate 3 and the underplate 4 depending on the form of an air spring, there should just be a member for attaching a voice coil motor in an air spring in that case.
[0029] Inserting in the above-mentioned crevice [winding] 9 between the magnets formed so that a voice coil 8 might be minded, the crevice 9 in a circle might be minded [which attached the voice coil motor 2 in the finish plate 3 / in a circle / 7] for this and a magnetic pole might counter radial, a magnet consists of the pole piece 11 of the permanent magnet 10 magnetized by N pole like illustration at the center side, and the iron core 12 in a circle magnetized by the outside at the south pole.
[0030] 13 is an acceleration sensor and 14 is a displacement sensor.
[0031] Drawing 2 is the main cross section of the vibration isolator of the second example. This example shows the example which built air spring 1' in the interior of voice coil motor 2'.
[0032] Air spring 1' consists of what prepared bag body 5' of the same rubber membrane as the first example between the magnet of voice coil motor 2' prepared between the finish plate 3 and the underplate 4, and the finish plate 3, and the compressed air is enclosed with the air chamber 6'.
[0033] Like the first example, voice coil motor 2' inserts a bobbin 7 and a voice coil 8 in a crevice 9, and consists of the permanent magnet 10 which has this crevice 9, and the pole piece 11 and the iron core 12 prepared in the outside. It has the acceleration sensor 13 and the displacement sensor 14 similarly.
[0034] Vibration of the device which the compressed air is sent into an air spring 1 and 1', and adjusts pneumatic pressure suitably when using it as a vibration isolator in any [of two examples constituted as mentioned above] case, and exerts electromagnetic force on a voice coil motor 2 and 2', and is installed in the upper part of a vibration isolator is prevented.
[0035] Drawing 3 is the main cross section of the vibration isolator of the third example. Although the electromagnetic-force oscillating absorber is built in the interior of an air spring 1 like the first example in this example, the composition of an electromagnetic-force oscillating absorber differs in a voice coil motor 2, and it differs in that electromagnet unit 2" which consists of the combination of an electromagnet and a permanent magnet is used.
[0036] Electromagnet unit 2" attaches in a finish plate what surrounded permanent magnet 7" by iron core 8", and consists of what looped this around coil 11" in a circle to predetermined distance ******** eclipse ****** 10." The acceleration sensor 13 and the displacement sensor 14 are formed too.
[0037] An air spring 1 forms a bag body 5 between a finish plate 3 and a underplate 4 like the first

example, and consists of what enclosed the compressed air with the interior.
[0038] Also in the vibration isolator of the above-mentioned composition, static height adjusts the pneumatic pressure of an air spring 1 based on the displacement information acquired from a displacement sensor 14, and performs it. Attenuation of vibration is made to act so that the electromagnetic force of electromagnet unit 2" may be adjusted based on the acceleration signal of an acceleration sensor 13 and vibration may be negated.
[0039] The plan of the example which formed the vibration isolator of one of the above on the vibrationproofing base 20 or in the bottom at drawing 4 is shown.
[0040] The outline block diagram of the control circuit which controls the vibration isolator of the first example of the above to drawing 5 is shown. In addition, it will not be necessary to explain that it is controllable by the same control circuit, even if it is the thing of the second example and the third example, although the example of illustration shows the thing of the first example as a vibration isolator.

[0041] If this control circuit consists mainly of three equalization circuits and one of them detects an acceleration signal by the acceleration sensor 13, after a filter's 21 removing DC component (direct current) among the acceleration signal, taking out only a change signal component, and the gain-adjustment machine's 22 adjusting gain and adding with other signals through an adder 25, it is the circuit which controls power amplification 26 based on the signal, and sends drive current to a voice coil motor 2.
[0042] An integrator 23 and the gain-adjustment machine 24 are formed in the circuit of the above-mentioned gain-adjustment machine 22 in parallel, and the output signal is sent to it to an adder 25.
[0043] The 2nd equalization circuit is the system of the displacement signal by the displacement sensor 14, and is a circuit which will differentiate the signal with a differentiator 27 if a displacement signal is taken out, carries out the gain adjustment of the differential signal with the gain-adjustment vessel 28, and is added to an adder 25.
[0044] It is a circuit which controls reducing-valve 33' while the 3rd equalization circuit branches, sends the displacement signal of the above-mentioned displacement sensor 14 to the gain-adjustment machine 29, adds this to an adder 32 and controls a regulator valve 33 by the output signal. The circuit of an integrator 30 and the gain-adjustment machine 31 is established in the circuit of the gain-adjustment machine 29, and parallel in the circuit which controls this regulator-valve 33 grade. A regulator valve 33 adjusts the compressed air from the high-pressure air receiver 34, and adjusts a variation rate in the height of an air spring 1. Reducing-valve 33' is adjusted so that the internal pressure of an air spring 1 may become below the set point.
[0045] As mentioned above, the signal which expresses the change portion with an adder 25 except for a part for the direct current from an acceleration signal, the signal which integrated with the signal, and the signal which differentiated the signal further detected by the displacement sensor 14 are added, and excitation of a voice coil motor is controlled by the above-mentioned control circuit by the output. That is, PID control is performed.
[0046] In this case, an output signal is given to power amplification 26 by the signal component with the large rate of one of signals among the values to which time for each signal to become the largest differed according to the property of each change, therefore the first acceleration signal, the speed signal which integrated with this, and the differential signal of a variation rate were added with the adder 25, and a voice coil motor 2 is excited so that the change may be negated by the exciting current from power amplification 26.
[0047] On the other hand, a displacement signal and its integration signal are given to an adder 32 in the circuit which controls regulator-valve 33 grade by the signal of a displacement sensor 14. The opening of a regulator valve 33 and the set pressure of reducing-valve 33' are controlled by the signal with the large rate for which each signal accounts also in this case, and it is adjusted so that the pneumatic pressure in an air spring 1, therefore the height position of a finish plate 3 may serve as the set point.
[0048] Although the above was the example of the circuit which enforces the first control method, a part of above circuit should be combined as other examples of the control method (following illustration

ellipsis).
[0049] For example, it is the combination (Systems I and III should put together) of the circuit which controls a voice coil motor by the above-mentioned acceleration sensor 13 as the second control method, and the circuit which controls regulator-valve 33 grade by the displacement sensor 14. Therefore, the circuit which sends the signal of a displacement sensor 14 to a differentiator 27 in this case is omitted.
[0050] The signal which differentiated the signal of a displacement sensor 14 with the differentiator 27 becomes the thing same as a result since it is a speed signal as the signal which integrated with the signal of an acceleration sensor 13, therefore even if it omits the circuit of a differentiator 27, it can perform the same control as the first control method.
[0051] The combination (Systems II and III should put together) of the circuit which forms only a displacement sensor 14, gives the signal to power amplification 26 through a differentiator 27 as the third control method, controls a voice coil motor 2, and controls regulator-valve 33 grade by the signal of the browning grade sensor 14 is employable. In this case, since the acceleration sensor 13 is not formed, an adder 25 is also omitted.
[0052] A voice coil motor 2 is controlled by the above-mentioned control circuit by the excitation from power amplification 26 to negate the variation rate of the size of the speed in proportion to the size of the speed signal of the circuit of System II. System III About an operation, it is the same as the case of the first example.
[0053] Therefore, also in this example, adjustment of the electromagnetic control of a voice coil motor 2 and the pneumatic pressure of the air spring by the regulator valve 33 is performed.

[Translation done.]

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DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] The main cross section of the vibration isolator of the first example
[Drawing 2] The main cross section of the vibration isolator of the second example
[Drawing 3] The main cross section of the vibration isolator of the third example
[Drawing 4] The plan at the time of installing one of examples in a vibrationproofing base
[Drawing 5] The outline block diagram of the control circuit for enforcing the method of controlling the above-mentioned vibration isolator
[Drawing 6] The cross section of the air spring of the conventional example
[Drawing 7] The plot plan of the vibration isolator formed on the vibrationproofing base of the conventional example
[Description of Notations]
1 1' Air spring
2 2' Voice coil motor
3 Finish Plate
4 Underplate
5 5' Bag body
6 6' Air chamber
7 Bobbin
7" Permanent magnet
8 Voice Coil
8" Iron core
9 Crevice
10 Permanent Magnet
10" Iron core
11 Pole Piece
11" Coil
12 Iron Core
13 Acceleration Sensor
14 Displacement Sensor

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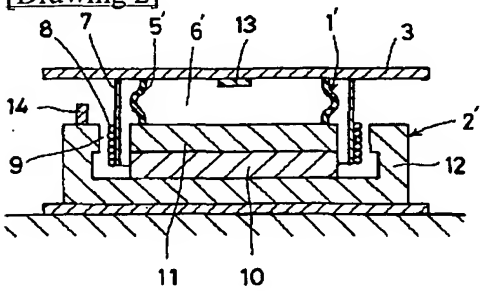
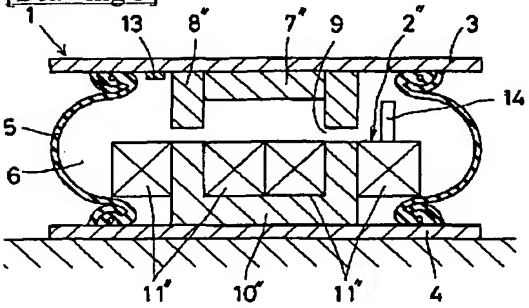
DRAWINGS

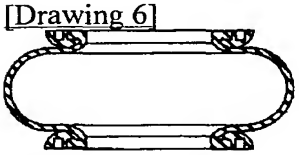
[Drawing 2]



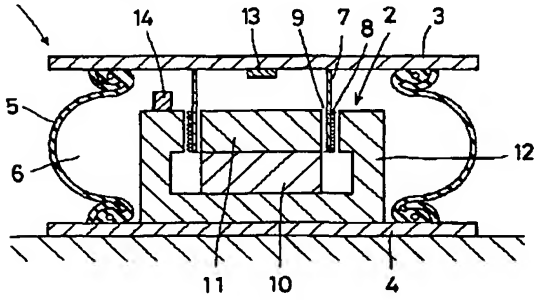
[Drawing 3]



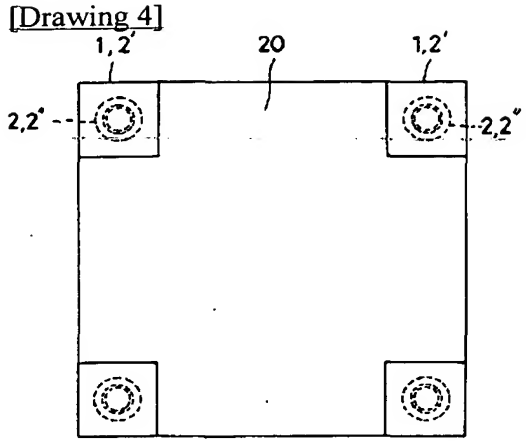
[Drawing 6]



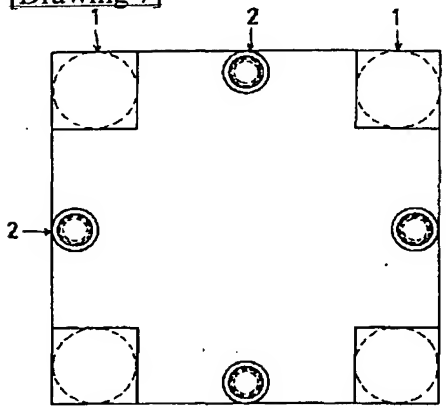
[Drawing 1]



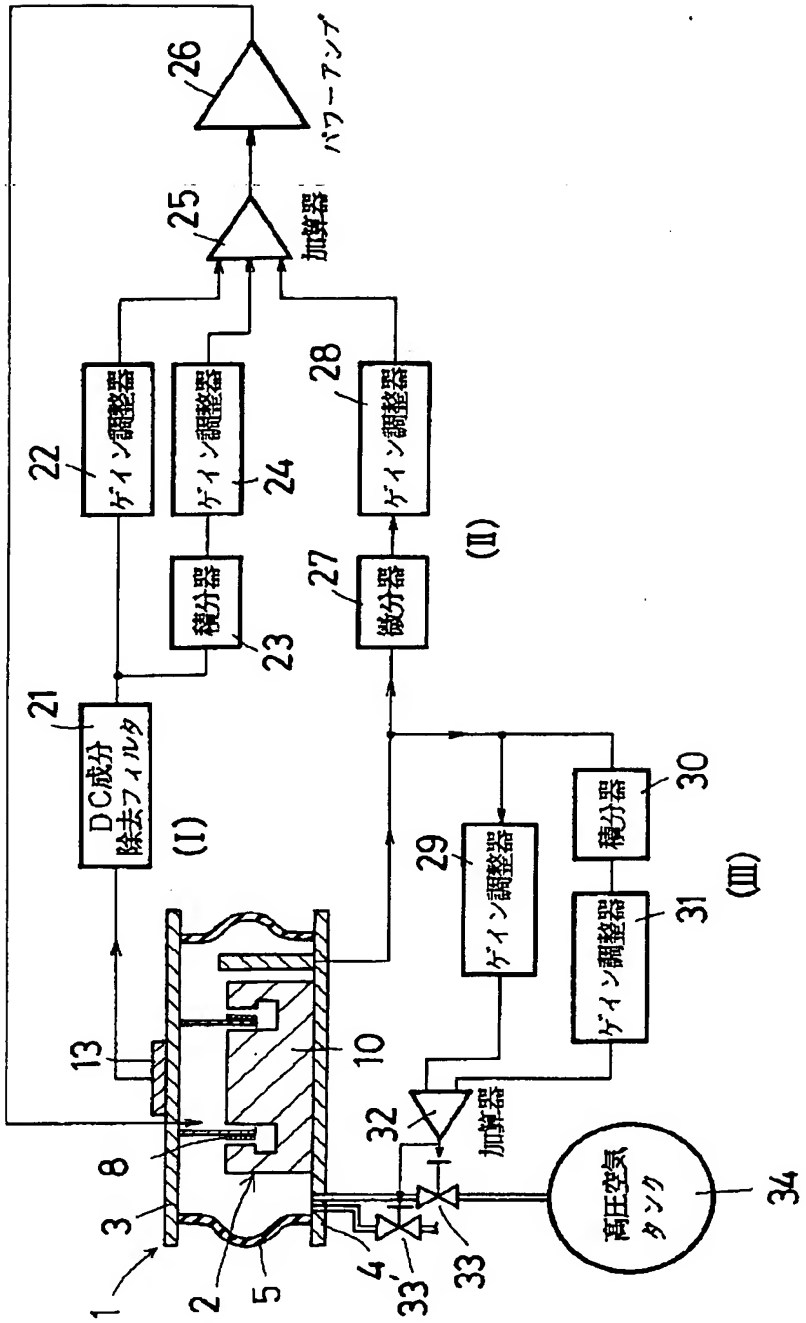
[Drawing 4]



[Drawing 7]



[Drawing 5]



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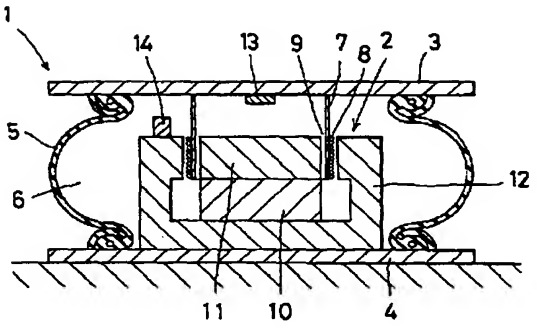
(54)【発明の名称】　防振装置及びその制御方法

(57)【要約】

【目的】　各種産業機械の振動を微振動まで高精度に防振する装置として空気ばねと電磁振動吸収体を一体化し、コンパクトで小型なものとし、これらを一体化した状態で制御することにより振動を防止する。

【構成】　防振装置は、空気ばね１の内部にボイスコイルモータ２を内蔵したものから成る。空気ばね１は上、下板３、４の間を袋体５で密封し、空気室６に圧縮空気を送り込む。空気室６内に設けたボイスコイルモータ２は、ボビン７にボイスコイルモータ８を巻装しこれを隙間９を有する永久磁石１０のポールピース１１と円環状の鉄心１２との間に挿置されて成る。



1

【特許請求の範囲】

【請求項1】　空気ばねと電磁力振動吸収体を備え、そのいずれか一方を他方の内部に設けて一体化したことを特徴とする防振装置。

【請求項2】　前記空気ばねを、気密弾性膜から成る袋体の内部に圧縮空気を封入したものとし、電磁力振動吸収体を、円筒部材にボイスコイルを巻装しこれを半径方向に磁極が対向する環状磁石間の空隙内に挿置して成るボイスコイルモータとしたことを特徴とする請求項1に記載の防振装置。

【請求項3】　前記空気ばね内に電磁力振動吸収体を備えて一体化し、電磁力振動吸収体は電磁石と、電磁石によって吸収力又は反発力を発生させる物体を電磁石に対し微小ギャップを設けて対向配置したものから成ることを特徴とする請求項1に記載の防振装置。

【請求項4】　空気ばねと電磁力振動吸収体のいずれか一方を他方の内部に一体化して設けた防振装置に対して、防振装置に取付けた加速度センサの出力信号とその積分信号のいずれか又は両方に基づいて振動吸収体の振動をフィードバック制御により電磁的に制御し、かつ空気ばねの圧縮量を検出する変位センサの出力信号とその積分信号のいずれか又は両方に基づいて空気ばね圧縮量が設定値になるように空気圧を制御することから成る防振装置の制御方法。

【請求項5】　前記防振装置に対して、空気ばねの圧縮量を検出する変位センサの出力信号を微分し、その微分信号に基づいて振動吸収体の振動をフィードバック制御により電磁的に制御し、かつ上記変位センサの出力信号とその積分信号のいずれか又は両方に基づいて空気ばね圧縮量が設定値になるように空気圧を制御することを特徴とする請求項4に記載の防振装置の制御方法。

【発明の詳細な説明】

【0001】

【産業上の利用分野】この発明は、種々の産業機械の防振に利用される防振装置及びその制御方法に関する。

【0002】

【従来の技術】脱水機、コンプレッサ、エアハンマ、プレス、振動コンベアなど各種産業機械から発生する振動を防止する手段の1つとして、空気ばねがある。この空気ばねは、図6に示すように一般に断面長円状の袋体の内部に圧縮空気を封入しその弾性を利用したものであり、強力なタイヤコードで補強された気密性の優れたゴム膜（ゴムベローズ）を上下金具で固定したものから成る。

【0003】かかる空気ばねを防振装置として使用する場合、図7に示すように一般に空気ばね1とボイスコイルモータ2のそれぞれ独立なものを必要数共通台の上に設置したものから成る。

【0004】上述した空気ばねを用いた防振装置は、例えば日本機械学会論文集（C編）、56巻523号（1990－3）に発表された研究論文（論文No．89－0916B）、「リニアモータを用いたアクティブ微振動除振装置の研究」（藤田隆史他4名）にその一例が示されている。

2

【0005】この研究論文では、除振装置のアクチュエータとしてボイスコイル形リニアモータが用いられ、空気ばねは搭載機器の重量変化に対して支持テーブルが定位置を保つように空気圧制御されている。そして、上記リニアモータコイルは、空気圧制御とは別個に、加速度センサによる加速度信号を検出しこれを積分器で速度信号に、さらに積分して変位信号を得、これらをディジタル信号に変換した後コンピュータ制御により制御されている。

【0006】従来の防振装置の他の一例として、同じく日本機械学会論文集（C編）、57巻534号（1991－2）に発表された研究論文（論文No．90－0829A）、「精密除振装置のアクティブコントロール」（岩田義明他4名）に精密除振装置が記載されている。

【0007】この例の除振装置はアクティブ系とされ、前記第一の研究論文のようにリニアコイルモータは設けられておらず、その代り空気ばねに空気源から送り込まれる空気量を入口付近に設けたサーボバルブを制御する方法が採用されている。この制御システムは台に設置された加速度センサと、台とベース間に設けた変位センサからの信号を積分器を介して制御系に送り、相対変位、加速度、速度信号に基づく指令信号によりサーボバルブの開閉を制御し内圧を制御するものである。

【0008】

【発明が解決しようとする課題】ところで、前述した第二の研究論文でも指摘しているように、電子顕微鏡、レーザ装置や半導体関係などの精密加工機械の高精度、高速化に行なって、測定精度や加工精度は1nmが現実の目標とされ、微小振動の影響が直接機器の性能を左右するまでとなっている。

【0009】従って、超精密機器等では空気ばねなどを設けるだけの受動的な防振装置では微小振動を許容範囲内に抑制することは困難であり、積極的に微小振動を除去できる能動的な防振装置が所望されている。そして、上記2つの研究論文はいずれも能動的な防振装置を目的とするものである。

【0010】しかしながら、上記2つの研究論文による防振装置は、第一のものでは空気ばねとリニアコイルモータがそれぞれ独立に台上に適宜配置で分散して設けられているため、機器全体が大型となりコストが増大する。制御方法としては、空気ばねの空気圧制御と加速度センサによるリニアモータのフィードバック制御がそれぞれ別個の系統として行なわれるため、超微小な除振条件を満足させるにはなお不足であるという問題がある。

【0011】又、第二の研究論文によるものでは、空気ばねの内圧をサーボバルブにより制御する方法を採用し

ているため、機器の大型化は避けられるが、空気ばねの超微小変位を内圧だけで制御するのはやはり振動抑制効果が不十分であり、第一の研究論文のようにリニアコイルモータによる制振力を併用する方が効果が大きい。

【００１２】さらに、空気ばねの固有振動数は数Ｈｚのものが得られ、低周波の防振が可能であるが、反面固有振動数付近では振幅が入力の数倍にも増幅されるという問題があり、低周波の防振においては防振効果に限界がある。

【００１３】この発明は、上述した従来の空気ばねを用いた防振装置の現状に留意して、空気ばねと電磁振動吸収体を一体化して構成することによって低い固有振動数の振動から極めて微小な高い振動数の振動までを防振し得るコンパクトで小型化した経済的に安価な防振装置を提供することを課題とする。

【００１４】さらに上記一体化された防振装置に対し、空気ばねの空気圧制御と電磁振動吸収体の励磁を同時に行なって防振装置による振動除去を有効に作用させ微小振動までを完全に除去し得る制御方法を提供することをもう１つの課題とする。

【００１５】

【課題を解決するための手段】上記第一の課題を解決する手段としてこの発明では、空気ばねと電磁力振動吸収体を備え、そのいずれか一方を他方の内部に設けて一体化した防振装置の構成としたのである。

【００１６】この場合、前記空気ばねを、気密弾性膜から成る袋体の内部に圧縮空気を封入したものとし、電磁力振動吸収体を、円筒部材にボイスコイルを巻装しこれを半径方向に磁極が対向する環状磁石間の空隙内に挿置して成るボイスコイルモータとした防振装置の構成としてもよい。

【００１７】あるいは、前記空気ばね内に電磁力振動吸収体を備えて一体化し、電磁力振動吸収体は電磁石と、電磁石によって吸収力又は反発力を発生させる物体を電磁石に対し微小ギャップを設けて対向配置したものとした防振装置の構成としてもよい。

【００１８】又、第二の課題を解決する手段としてこの発明では、空気ばねと電磁力振動吸収体のいずれか一方を他方の内部に一体化して設けた防振装置に対して、防振装置に取付けた加速度センサの出力信号とその積分信号のいずれか又は両方に基づいて振動吸収体の振動をフィードバック制御により電磁的に制御し、かつ空気ばねの圧縮量を検出する変位センサの出力信号とその積分信号のいずれか又は両方に基づいて空気ばね圧縮量が設定値になるように空気圧を制御することから成る防振装置の制御方法としたのである。

【００１９】この場合は、前記防振装置に対して、空気ばねの圧縮量を検出する変位センサの出力信号を微分し、その微分信号に基づいて振動吸収体の振動をフィードバック制御により電磁的に制御し、かつ上記変位センサの出力信号とその積分信号のいずれか又は両方に基づいて空気ばね圧縮量が設定値になるように空気圧を制御するようにした制御方法としてもよい。

【００２０】

【作用】上記構成の防振装置は、制御方法の発明による方法で制御される。防振装置の制御は空気ばねの空気圧を制御することと、振動を直接的能動的に制御することの２面から行なわれる。

【００２１】空気ばね自体の固有振動数は、この発明の場合も極めて低く数Ｈｚ程度である。空気圧をその支持荷重の大きさによって最も減衰率が大きくなるように調整する。この調整は調整弁の開度を変位センサの信号に基づいて制御することによって行なわれる。

【００２２】調整弁を制御する場合、変位センサの信号とその積分信号の組合せにより行なわれ、変位センサ信号の大きさに直接比例して変位を最小とするようにし、かつ積分信号は所定時間内の変位信号の平均値となる値に制限するのに用いる。これによって大まかな振動は殆んど減衰できる。

【００２３】電磁振動吸収体は、ボイスコイルモータあるいは電磁石を組合せたもののいずれかが用いられるが、振動吸収作用としては基本的には同じであり、支持負荷からの振動による変位を加速度としてあるいは変位を直接的に測定することによりその信号をフィードバックして電磁的に反作用を与え、それによって振動を打消すように作動する。

【００２４】この電磁力による反作用力は極めて微小な変位に対しても有効に作用し、空気ばね内でこれと一体化した構造のものに作用させることによって振動を完全に抑制することができるのである。

【００２５】

【実施例】以下この発明の実施例について図面を参照して説明する。

【００２６】図１は第一実施例の防振装置の主要断面図である。この実施例は空気ばね１の内部に電磁力振動吸収体としてのボイスコイルモータ２を内蔵した例を示す。

【００２７】空気ばね１としては、通常のものと同様に上板３、下板４の間に強力なタイヤコードで補強された気密性の秀れたゴム膜（ゴムベローズ）から成る断面長円状の袋体５を取付けたものであり、内部の空気室６には圧縮空気が封入され、その弾性を利用して空気ばねを形成している。

【００２８】空気ばねの形式によっては上板３、下板４を設けていないものもあるが、その場合は空気ばね内にボイスコイルモータを取付けるための部材があればよい。

【００２９】ボイスコイルモータ２は、上板３に取付けた円環状のボビン７にボイスコイル８を巻回し、これを円環状の隙間９を介して半径方向に磁極が対向するよう

に形成した磁石の上記隙間９に挿入し、磁石は例えば図示のように中心側にＮ極に磁化された永久磁石１０のポールピース１１とその外側にＳ極に磁化された円環状の鉄心１２とから成る。

【００３０】１３は加速度センサ、１４は変位センサである。

【００３１】図２は第二実施例の防振装置の主要断面図である。この実施例では空気ばね１’をボイスコイルモータ２’の内部に内蔵した例を示す。

【００３２】空気ばね１’は、上板３と下板４の間に設けられたボイスコイルモータ２’の磁石と上板３の間に第一実施例と同様なゴム膜の袋体５’を設けたものから成り、その空気室６’に圧縮空気が封入される。

【００３３】ボイスコイルモータ２’は、第一実施例と同様に、ボビン７、ボイスコイル８を隙間９に挿入し、この隙間９を有する永久磁石１０とそのポールピース１１、その外側に設けた鉄心１２とから成る。加速度センサ１３、変位センサ１４を同様に備えている。

【００３４】以上のように構成した２つの実施例のいずれの場合も、防振装置として使用するときは空気ばね１、１’に圧縮空気が送り込まれ空気圧を適宜調節し、かつボイスコイルモータ２、２’には電磁力を及ぼして防振装置の上部に設置される機器の振動が防止される。

【００３５】図３は第三実施例の防振装置の主要断面図である。この実施例では、第一実施例と同様に空気ばね１の内部に電磁力振動吸収体が内蔵されているが、電磁力振動吸収体の構成はボイスコイルモータ２とは異なり、電磁石と永久磁石の組合せから成る電磁石ユニット２”が使用されている点が異なっている。

【００３６】電磁石ユニット２”は、永久磁石７”を鉄心８”で囲んだものを上板に取り付け、これに所定距離置いて設けられた鉄心１０”に円環状のコイル１１”を巻装したものから成る。加速度センサ１３、変位センサ１４をやはり設けてある。

【００３７】空気ばね１は、第一実施例と同様に上板３と下板４の間に袋体５を設け、内部に圧縮空気を封入したものから成る。

【００３８】上記構成の防振装置においても、静的な高さは変位センサ１４から得られる変位情報に基づいて空気ばね１の空気圧を調整して行なう。振動の減衰は加速度センサ１３の加速度信号に基づいて電磁石ユニット２”の電磁力を調整して振動を打ち消すように作用させる。

【００３９】図４に、上記いずれかの防振装置を防振台２０の上又は下に設けた例の平面図を示す。

【００４０】図５に、上記第一実施例の防振装置を制御する制御回路の概略ブロック図を示す。なお、図示の例では防振装置として第一実施例のものを示しているが、第二実施例、第三実施例のものであっても同様な制御回路により制御できることは説明するまでもないであろう。

【００４１】この制御回路は、主として３つの調整回路から成り、その１つは加速度センサ１３により加速度信号を検出するとその加速度信号のうちＤＣ成分（直流）をフィルタ２１により除去し、変動信号成分のみを取り出してゲイン調整器２２によりゲインを調整し、加算器２５を介して他の信号と加算した後その信号に基づいてパワーアンプ２６を制御して駆動電流をボイスコイルモータ２へ送る回路である。

【００４２】上記ゲイン調整器２２の回路には、並列に積分器２３とゲイン調整器２４が設けられ、その出力信号は加算器２５へ送られる。

【００４３】第２の調整回路は、変位センサ１４による変位信号の系であり、変位信号を取り出すと微分器２７によりその信号を微分し、微分信号をゲイン調整器２８でゲイン調整して加算器２５へ加える回路である。

【００４４】第３の調整回路は、上記変位センサ１４の変位信号を分岐してゲイン調整器２９へ送り、これを加算器３２へ加算してその出力信号により調整弁３３を制御すると共に減圧弁３３’を制御する回路である。この調整弁３３等を制御する回路にはゲイン調整器２９の回路と並列に積分器３０及びゲイン調整器３１の回路が設けられている。調整弁３３は高圧空気タンク３４からの圧縮空気を調整して空気ばね１の高さ変位を調整する。減圧弁３３’は空気ばね１の内圧が設定値以下となるように調整する。

【００４５】上記制御回路では、上述したように加算器２５には加速度信号からその直流分を除きその変化部分を表わす信号と、その信号を積分した信号と、さらに変位センサ１４で検出された信号を微分した信号とが加えられ、その出力によってボイスコイルモータの励磁が制御される。つまり、ＰＩＤ制御が行なわれる。

【００４６】この場合、第一の加速度信号と、これを積分した速度信号と、変位の微分信号は、それぞれの信号が最も大きくなる時間がそれぞれの変化の性質に応じて異なり、従って加算器２５で加算された値のうちいずれかの信号の割合の大きい信号成分によって出力信号がパワーアンプ２６に与えられ、パワーアンプ２６からの励磁電流によってその変化を打消すようにボイスコイルモータ２が励磁される。

【００４７】一方、変位センサ１４の信号によって調整弁３３等を制御する回路では、加算器３２に対して変位信号とその積分信号が与えられる。この場合も、それぞれの信号の占める割合の大きい信号によって調整弁３３の開度及び減圧弁３３’の設定圧が制御され、空気ばね１内の空気圧、従って上板３の高さ位置が設定値となるように調整される。

【００４８】以上が第一の制御方法を実施する回路の実施例であるが、制御方法の他の例としては以上の回路の一部を組合せたものとすることもできる（以下図示省

略）。

【００４９】例えば、第二の制御方法として上記加速度センサ１３によりボイスコイルモータを制御する回路と、変位センサ１４により調整弁３３等を制御する回路の組合せ（系ＩとIII の組合せ）である。従って、この場合は変位センサ１４の信号を微分器２７へ送る回路は省略される。

【００５０】変位センサ１４の信号を微分器２７で微分した信号は速度信号であるから、加速度センサ１３の信号を積分した信号と結果的には同じものとなり、従って微分器２７の回路は省略しても第一の制御方法と同様な制御が行なえる。

【００５１】第三の制御方法としては、変位センサ１４のみを設けその信号を微分器２７を介してパワーアンプ２６へ与えてボイスコイルモータ２を制御し、かつ変位センサ１４の信号で調整弁３３等を制御する回路の組合せ（系IIとIII の組合せ）を採用することができる。この場合は、加速度センサ１３が設けられていないから、加算器２５も省略される。

【００５２】上記制御回路では、系IIの回路の速度信号の大きさに比例してその速度の大きさの変位を打消すようにパワーアンプ２６からの励磁によりボイスコイルモータ２が制御される。系III の作用については第一の実施例の場合と同じである。

【００５３】従って、この実施例においてもボイスコイルモータ２の電磁制御と、調整弁３３による空気ばねの空気圧の調整が行なわれる。

【００５４】

【効果】以上詳細に説明したように、この発明では空気ばねと電磁力振動吸収体をいずれかを他方内に内蔵し一体化した防振装置の構成としたから、装置全体をコンパクトで小型化したものとし、かつコストを低減でき、防振装置全体の設計配置が有利になるなどの利点が得られる。

【００５５】上記防振装置を制御する方法の発明では、加速度信号とその積分信号の組合せで振動吸収体の振動を電磁的に制御しかつ変位センサの信号とその積分信号の組合せにより空気ばねの空気圧を制御する第一の制御方法、あるいは変位センサの信号を微分した信号により振動吸収体の振動を電磁的に制御しかつ変位センサ信号とその積分信号の組合せにより空気ばねの空気圧を制御する第二の制御方法のいずれの場合であっても、一体化構造とした振動吸収体の振動を電磁的に打消すと共に空気ばねの空気圧を調整する方法の組合せとしたから、いずれか一方のみの制御又はそれぞれを個別に別体構造の振動吸収体に対して行なう従来の方法に比べると、格段に高精度な微小振動の抑制が可能となる。

【図面の簡単な説明】

【図１】第一実施例の防振装置の主要断面図

【図２】第二実施例の防振装置の主要断面図

【図３】第三実施例の防振装置の主要断面図

【図４】いずれかの実施例を防振台に設置した場合の平面図

【図５】上記防振装置を制御する方法を実施するための制御回路の概略ブロック図

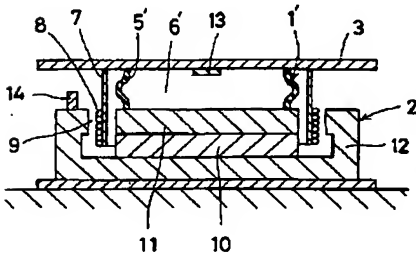
【図６】従来例の空気ばねの断面図

【図７】従来例の防振台上に設けた防振装置の配置図

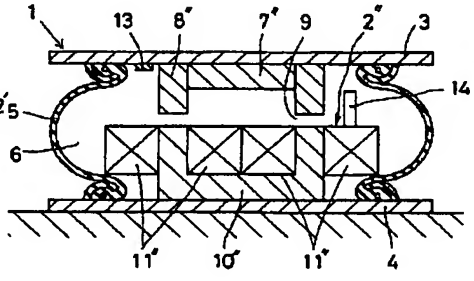
【符号の説明】

１、１’　空気ばね
２、２’　ボイスコイルモータ
３　上板
４　下板
５、５’　袋体
６、６’　空気室
７　ボビン
７”　永久磁石
８　ボイスコイル
８”　鉄心
９　隙間
１０　永久磁石
１０”　鉄心
１１　ポールピース
１１”　コイル
１２　鉄心
１３　加速度センサ
１４　変位センサ

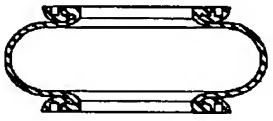
【図２】



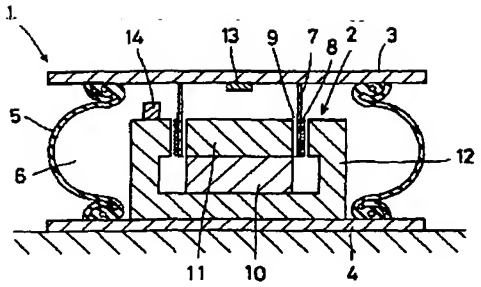
【図３】



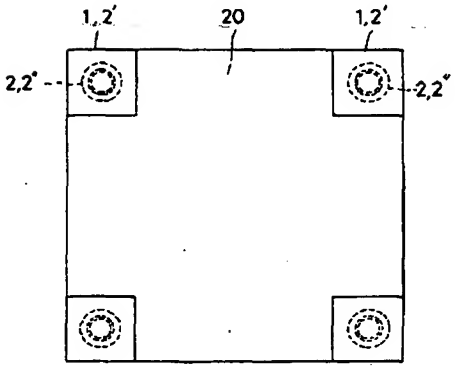
【図６】



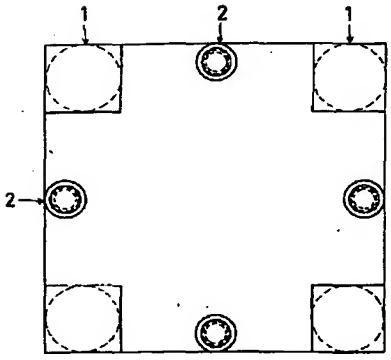
【図1】



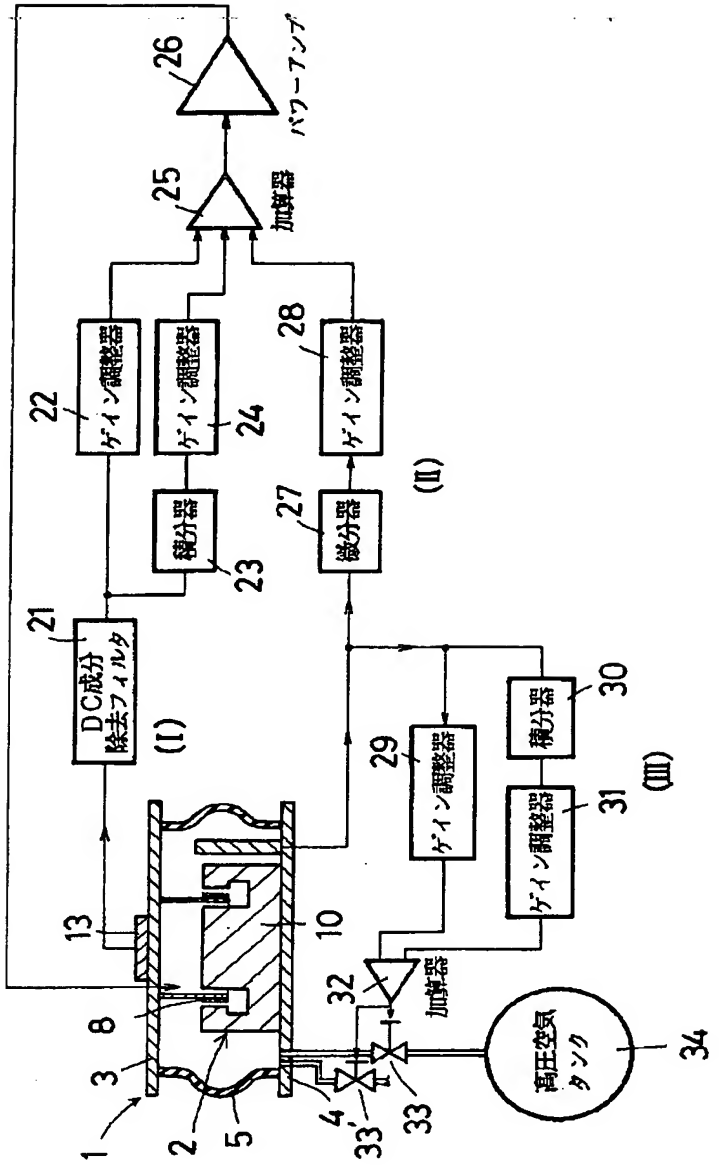
【図4】



【図7】



【図5】


パワーアンプ
加算器
ゲイン調整器
積分器
微分器
DC成分除去フィルタ
(I)
(II)
(III)
高圧空気タンク
1
2
3
4
5
8
10
13
21
22
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32
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33'
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